

### **Remarks**

This Amendment is made in response to the non-final Office Action of March 16, 2010. The Office Action has been carefully reviewed, and the following remarks are considered responsive thereto.

Claims 1–18 are pending in the present application, prior to entry of this Amendment. Claims 6–12 and 14–18 were amended in a Preliminary Amendment filed June 6, 2006. Claims 1, 4–5, 10, and 17 were amended via an Amendment and Response to a first Office Action filed December 17, 2010, and new claim 19 was added. Clarifying amendments have been made in the present Amendment to independent claim 1 to place the claim in condition for allowance. Further clarifying amendments have also been made to dependent claims 9, 10, 15, 17, and 19, primarily to make these claims consistent with amendments made to the independent claims. New claims 20–24 have been added by this Amendment. Claims 2–8, 11–14, and 18 have been canceled by this Amendment.

It is submitted that no new matter is presented by this Amendment, as all claim amendments and new claims are properly supported by the application as originally filed. In view of the amendments and remarks which follow, reconsideration and allowance of the application and claims is respectfully requested.

The following sections correspond to the sections in the Office Action.

### ***Drawings***

In the Office Action, FIG. 4 was objected to for not including a legend, such as “Prior Art”, because it was asserted that “only that which is old is illustrated.” A corrected drawing in compliance with 37 C.F.R. § 1.121(d) was therefore required.

In response, Applicants submit herewith a replacement drawing for FIG. 4 that includes a “Prior Art” designation immediately underneath the figure. As recited in the as-filed specification, FIG. 4 illustrates a micropiston that was fabricated using a lithographic process as described in K. Jiang and P. Jin, *Microfabrication of ultra-thick SU-8 photoresist for microengines*, Proc SPIE Photowest Micromachining and Microfabrication 2003, San Jose, California, 25-31 (Jan. 2003).

Additionally, in the Office Action, FIGS. 1 and 2 were objected to under 37 C.F.R. § 1.83(a) because the original figures fail to show the reference numerals discussed in the specification associated with the figures, such as microengine (10), piston (12), piston cylinder (14), etc. Corrected drawings in compliance with 37 C.F.R. § 1.121(d) were therefore required.

In response, Applicants submit that the element numbers for FIGS. 1 and 2 are not necessarily essential for an understanding of the presently-claimed invention, as the present claims are directed to a lithographic process, and thus Applicant believes the requirement that FIGS. 1 and 2 be labeled is improper and should be withdrawn. However, to provide a better understanding and description of the subject matter in the present application, and to comply with the Examiner's request, FIGS. 1 and 2 have been amended to illustrate appropriate reference numbers. Specifically, a replacement sheet that illustrates the reference numerals discussed in the as-filed specification in connection with the discussed drawing elements is submitted herewith.

Accordingly, it is believed that submission of the replacement drawing sheet attached hereto sufficiently addresses the Examiner's objection to various drawing figures, and it is respectfully requested that such drawing objections be withdrawn.

### ***Claim Rejections - 35 U.S.C. § 112***

In the Office Action, claim 18 was rejected under 35 U.S.C. § 112, second paragraph, as being indefinite for failing to particularly point out and distinctly claim the subject matter which the Applicants regard as their invention. Specifically, the Office Action asserts that the "specification disclosure fails to use the processing step claimed in the claimed process to produce a component 'a reciprocating microengine comprising a cylinder, piston, and crankshaft presented in claim 18'". [Office Action, p. 3].

In response, Applicant has canceled claim 18 from the present application. Accordingly, it is believed that the cancellation of claim 18 sufficiently addresses the Examiner's rejection of this claim, and it is respectfully requested that such claim rejection be withdrawn.

Additionally, claims 1–19 were rejected under 35 U.S.C. § 112, second paragraph, on various grounds, discussed below.

Specifically, claims 1 and 4 (and their corresponding dependent claims) were rejected because the term “type” in “epoxy-type negative photoresist” is allegedly indefinite, and the Office Action indicated it was unclear whether the “type” characterizes the structure, composition, physical characteristics, etc. of the claimed photoresist. In response, Applicants submit that, at the time the application was filed, it would have been understood by one of ordinary skill in the art that the “type” term refers to the composition of the photoresist (i.e., it is made of an epoxy composition). For example, claim 1 in the *Warren* reference (cited by the Examiner in the present Office Action, and which relates to SU-8 photoresists) describes a photoresist being “formed by a lacquer containing a polyfunctional epoxy composition”. This indicates that SU-8 photoresists, such as those described in *Warren* and in the present application, are composed of an “epoxy-type” material.

Applicants believe the above discussion sufficiently addresses the Examiner’s rejection concerning the use of the term “type” in the claims. However, in order to comply with the Examiner’s request and move this case quickly towards allowance, the present claims have been amended to indicate that the photoresist is an “SU-8 photoresist.” It is believed that this amendment sufficiently addresses the Examiner’s rejection of these claims regarding the indefiniteness of the “type” term.

Regarding claims 1, 4, 17, and 19, the Office Action indicated that the terms “high aspect ratio” or “aspect ratio” are not clearly defined in the specification disclosure. Again, as with the word “type” discussed above, Applicants submit that, at the time the application was filed, the definition of aspect ratio would have been understood by one of ordinary skill in the art. Specifically, it was understood at the time the application was filed (and is still understood today) that an aspect ratio is a measure of a longer component of something to a shorter component. In the specific context of microstructures, aspect ratio relates to height (or depth) as compared to width. For example, as shown in the attached Exhibit A, which is a photograph of a microstructure produced by one of the presently-claimed processes, the vertical distance is the depth of the microstructure (or height of the structure coming out of the substrate), and the lateral measures of the grooves of the microstructure are the shorter distances. Thus, it was understood by those of ordinary skill in the art at the time the present application was filed that “aspect

ratio”, as that term is used in regards to lithographic processes and microstructures, meant depth of the microstructure to a lateral measure. Accordingly, it is believed that the above description adequately responds to the Examiner’s rejection regarding the term “aspect ratio,” and the rejection is hereby traversed.

Regarding claims 1 and 4 (and their respective dependent claims), the Office Action indicated that the term “exposed photoresist” is unclear as it lacks proper antecedent basis. In response, Applicants have amended the claims to simply describe “the photoresist”. It is believed that this amendment sufficiently addresses the Examiner’s rejection of these claims regarding this antecedent basis issue.

Regarding claims 1 and 4 (and their respective dependent claims), the Office Action indicated that the term “elevated temperature” is indefinite as the metes and bounds thereof cannot be determined from the specification. In response, Applicants have amended the claims to specify that the post-baking occurs at a “temperature of at least 60°C.”

Accordingly, it is believed that the various claim amendments and arguments discussed above have sufficiently addressed the 35 U.S.C. § 112 rejections raised in the Office Action, and it is respectfully requested that such claim rejections be withdrawn.

### ***Specification***

In the Office Action, claim 18 was objected to under 37 C.F.R. § 1.75(c), as being of improper dependent form for failing to further limit the subject matter of a previous claim.

Applicants are unclear as to why the rejection of claim 18 is listed under a “Specification” heading in the Office Action. Regardless, in an attempt to comply with the Examiner’s request, and to move this case quickly towards allowance, claim 18 has been canceled from the present application.

Accordingly, it is believed that the cancellation of claim 18 has sufficiently addressed the specification rejection raised in the Office Action, and it is respectfully requested that such rejection be withdrawn.

***Claim Rejections - 35 U.S.C. §§ 102, 103***

In the Office Action, claims 17–18 were rejected under 35 U.S.C. § 102(b), or in the alternative 35 U.S.C. § 103(a), as allegedly being anticipated by or unpatentable over either *Conradie, E. H. et al.*, “SU-8 Thick Photoresist Processing as a Functional Material for MEMS Applications”, or *Warren* (U.S. Patent Pub. No. 2002/0115016).

Additionally, claims 1–19 were rejected under 35 U.S.C. § 103(a) as allegedly being unpatentable over *Minsek et al.* (U.S. Patent No. 6,716,568), *Ohkubo et al.* (U.S. Patent No. 5,118,518), and *Zhong-geng Ling et al.*, “Improving Patterning Quality of SU-8 Microstructures by Optimizing the Exposure Parameters”, as well as pages 1–3 of the as-filed application.

In response, Applicants respectfully submit that the cited references are insufficient to support a 35 U.S.C. § 102(b) or 35 U.S.C. § 103(a) rejection of the present claims because the cited references, whether taken alone or in combination, simply do not teach, describe, or suggest the elements of the present claims, as amended. Further, Applicants submit herewith evidence of unexpected results of the claimed subject matter as further evidence of the nonobviousness and patentability of the present claims. Accordingly, Applicants respectfully request that the 35 U.S.C. §§ 102(b), 103(a) rejections of the claims based on the cited references be withdrawn.

**1. References Do Not Teach, Describe, or Suggest Claimed Subject Matter**

Although believed unnecessary for patentability, Applicants have amended the present claims to further clarify the claimed subject matter, and to differentiate the claims from the art of record. Specifically, representative amended claim 1 recites: A lithographic process for producing one or more microstructures from an SU-8 photoresist, wherein the SU-8 photoresist has a ***thickness greater than 0.7 mm***, comprising the steps of: (i) exposing a prebaked SU-8 photoresist on a substrate to light at a ***total energy density in a range of about 18,000 to 35,000 mJ/cm<sup>2</sup>***, wherein the light comprises a combination of wavelengths including 436nm, 405nm, and 365nm, and wherein the exposing further comprises: (a) exposing the SU-8 photoresist to the light without a filter; (b) exposing the SU-8 photoresist to the light ***with a first filter that filters about 80% of the light at 365nm***; (c) exposing the SU-8 photoresist to the light ***with a second filter that filters about 90% of the light at 365nm***; and (d) exposing the SU-8 photoresist to the

light *with a third filter that filters all of the light at 365nm*; (ii) post-baking the SU-8 photoresist at a temperature of at least about 60°C; and (iii) developing the SU-8 photoresist in a solvent, whereby a microstructure is produced.

Applicants respectfully submit that the cited references, whether taken alone or in combination, simply do not teach, describe, or suggest the elements of the present claims, as amended. Specifically, *none* of the cited references teach, discuss, or suggest a *multi-stage exposure* process, whereby *different filters* are used during each exposure stage to *filter out certain percentages of light at a particular wavelength, namely, 365nm*. Simply put, *none* of the cited references disclose or even remotely suggest *filtering out certain percentages of wavelengths during photoresist exposures*, much less *multiple stages* of exposures with *multiple filtering steps*. Accordingly, Applicants believe this reason alone is sufficient to warrant withdrawal of the 35 U.S.C. §§ 102(b), 103(a) rejections of the presently-amended claims. (However, as described in greater detail below, evidence of unexpected results based on the claimed process further strengthens the non-obviousness of the present claims.)

Additionally, in the Examiner's Interview Summary, mailed June 16, 2010, the Examiner states that "it was the examiner's position that [the previous claim step of filtering out at least 20% of the UV light emitted from a mercury lamp having a wavelength of 365nm] would have been found prima facie obvious unless there is a criticality of the at least 30% [Applicant believes Examiner meant 20%] of the UV light emitted from the mercury lamp of 365nm is provided." The Examiner further states that "[t]here is 80% of the wavelength of 365nm is still used in the irradiating steps, and this wavelength is the preferable waveleng[th] suggested by the manufacture[r] to expose[] the epoxy resin . . ."

In reply to the Examiner's Interview Summary, Applicants submit that the amended claims have clarified that *not just 20%* of the UV light emitted at 365nm is filtered out, but that about *80%, 90%, and all of the UV light emitted at 365nm is filtered out* during three separate exposure steps. Further, Applicants believe that the evidence of unexpected results (discussed below and in the attached Declaration Under 37 C.F.R. § 1.132) *demonstrates the criticality of the filtering of large percentages of UV light at 365nm* to the overall claimed process.

Further, in the Office Action, the Examiner admits that none of the cited references

disclose filtering of certain percentages of light at particular wavelengths; however, the Examiner asserts that the “scope of the wavelength [described by the previous claims] still encompasses the whole scope of uv wavelength taught in the applied prior art of record.” [Office Action, p. 10]. Applicants believe the Examiner’s statement here misses the point—Applicants are not arguing that their claimed process utilizes some wavelength of uv light not taught in any prior art, they are simply submitting that *actively filtering out certain percentages of a given wavelength* over a *multi-step process* produces a *profound and unexpected result* on SU-8 photoresists (and subsequent microstructures). In sum, active steps of exposing a photoresist via various filters is *not encompassed* within the scope of a general discussion of well-known wavelength ranges (which is all the prior art can be purported to suggest).

Because at least the above-referenced claim elements are not taught or described in *Minsek*, *Ohkubo*, *Conradie*, *Warren*, or *Zhong-geng Ling*, or any other known reference, whether taken alone or in combination, Applicants respectfully request that the 35 U.S.C. §§ 102(b), 103(a) rejection of claims 1, 9–10, 15–17, and 19 be withdrawn.

## **2. Evidence of Unexpected Results**

Applicants respectfully submit that because embodiments of the present claims produced unexpected (i.e., greater than expected) results, the present claims are nonobvious and should be allowable. As recited in MPEP § 716.02(a), greater than expected results are evidence of nonobviousness. “A greater than expected result is an evidentiary factor pertinent to the legal conclusion of obviousness . . . of the claims at issue.” [*In re Corkill*, 711 F.2d 1496 (Fed. Cir. 1985)]. “Evidence that a compound is unexpectedly superior in one of a spectrum of common properties . . . can be enough to rebut a *prima facie* case of obviousness.” [*In re Chupp*, 816 F.2d 643, 646 (Fed. Cir. 1987)].

Here, as recited below and in Dr. Jiang’s attached Declaration Under 37 C.F.R. § 1.132, Dr. Jiang (named inventor) performed experiments on processes embodying the currently-amended claim 1, as well as those embodying the believed closest prior art. The inventors of the presently-claimed subject matter had no expectation that filtering certain percentages of light at 365nm would produce high aspect ratio parts, as it is generally recommended by SU-8 suppliers

(i.e., manufacturers) to use 365nm as the optimum wavelength for exposure. In that regard, *it is counterintuitive to filter out certain portions of light that were recommended and supposedly preferable for exposure of photoresists*. In contrast to the inventors' expectations, however, tests of the currently-claimed processes produced high aspect ratio microstructures, on the order of greater than 10:1, and in some cases greater than 40:1. From the perspectives of the inventors, whom are experts in the field, the tests of the claimed invention(s) indicate a *marked improvement* in microstructures produced by lithographic processes.

Specifically, an embodiment of the present invention(s) as described by current claim 1 was tested according to various testing parameters (described in the attached Declaration Under 37 C.F.R. § 1.132). A control process was also tested, wherein the control process was identical to that of present claim 1, except that the exposure of the photoresist was carried out in a single step, and *no filtering of the 365nm light was performed*. The control process was believed to be the closest prior art that was commensurate in scope with the claims of the present application. The particular testing parameters of the experiments are described in item #5 in the attached Declaration Under 37 C.F.R. § 1.132 (pages 2–3). The tests were conducted in exactly the same manner for the embodiment of the present claims as for the control process.

As recited in Dr. Jiang's attached Declaration Under 37 C.F.R. § 1.132, these results of the tests indicated a *substantial improvement* over the closest prior art (i.e., a marked improvement in microstructures produced by lithographic processes). Specifically, tests of the embodiment of the present claims produced high aspect ratio microstructures, on the order of *greater than 10:1, and in some experiments greater than 40:1*. Attached "Exhibit A" illustrates a microstructure produced via the process described by present claim 1. As was understood by those of ordinary skill in the art at the time the present application was filed, the term "aspect ratio" generally refers to the ratio of a shape or structure's longer dimension as compared to its shorter dimension. In the field of photoresists, microstructures, and lithographic processes, an "aspect ratio" is commonly understood to mean the depth (or vertical distance) of a microstructure by any of its lateral measures (e.g., width of the part or microstructure).

In contrast, the tests of the prior art control process did *not* produce high aspect ratio microstructures. Attached "Exhibit B" illustrates a microstructure produced via the prior art



control process (i.e., *no filtering*). Although the top grooves (i.e., grooves closest to the exposed photoresist surface) of tested photoresists showed good definition, there was clear tapering and overall general non-linearity in the microstructures, beginning approximately 2/3 down the length of the microstructures (starting at the exposed photoresist surface) down to the base of the photoresist. Again, the tests of the claimed invention(s) indicate a marked improvement in microstructures produced by lithographic processes.

Additionally, as recited in the previous Response filed December 17, 2010, Applicants point out that the claimed lithographic processes enable processing of high-thickness photoresists (e.g., greater than 0.7 mm) to produce high aspect ratio parts (e.g., 10:1, or even 40:1, or greater). In the Office Action, the Examiner asserted that performing lithographic processes on photoresists of greater than 0.7 mm “would have been found *prima facie* obvious to the worker of ordinary skill in the art” because “[c]hanges in size, dimension, shape, proportion, or mere duplication of parts, are not sufficient to patentably distinguish over the prior art, *unless the recited changes are critical, i.e., they produce a new and unexpected result which is different in kind and not merely in degree from the result of the prior art.*” [Office Action, pp. 12-13 (emphasis added)]. As recited in Dr. Jiang’s attached Declaration Under 37 C.F.R. § 1.132, the experimental tests conducted demonstrated that “the filtering of light at 365nm *is critical to the ability to produce high aspect ratio microstructures from “thick” (i.e., thickness greater than 0.7 mm) photoresists.*” [Emphasis added]. During testing, it was found that SU-8 photoresists absorb the 365nm wavelength more than longer wavelengths. Thus, in a “thick” structure, the top part of the structure absorbs 365nm light first, and therefore becomes overexposed before sufficient light reaches the bottom part of the structure. The result of this overexposure causes the top part of the structure to grow sideways, resulting in an undesired “V” shape towards the bottom of the structure (see attached Exhibit B). In this way, for “thick” photoresists (i.e., those greater than 0.7 mm, as claimed), *filtering the light at 365nm is a critical element of the process.*

Applicants submit that the evidence of unexpected results corresponding to the claimed subject matter provides strong evidence of non-obviousness. Accordingly, based on the above reasons and others, Applicants respectfully request that the 35 U.S.C. §§ 102(b), 103(a)

rejections of the present claims be withdrawn.

\* \* \* \* \*

For the sake of brevity, not every claim or claim element and their associated rejections have been discussed. However, Applicants do not acquiesce in any of the Examiner's assertions and comparisons regarding the cited references and the present claims, regardless of whether they have been specifically addressed in this Amendment.

Additionally, although not all dependent claims were specifically discussed, because the dependent claims in the application merely provide additional elements or limitations to the independent claims from which they depend, they should also be allowable, on their own merits as providing unique additional functionality, and separately under the doctrine of *In re Fine*, 5 U.S.P.Q.2d 1597 (Fed. Cir. 1988), which stands for the proposition that if an independent claim is patentable, a dependent claim should also be patentable as it provides further limitations to the independent claim from which it depends.

Accordingly, it is believed that the foregoing amendments and arguments have addressed all of the claim rejections in the Office Action, and have thus placed all pending claims in condition for allowance. Such allowance is earnestly and respectfully solicited.

\* \* \* \* \*

**Conclusion**

For the foregoing reasons, it is submitted that all claims are believed novel, nonobvious, fully supported, and should be patentable in view of the art of record. The foregoing is submitted as a full and complete response to the non-final Office Action mailed March 16, 2010, and is believed to place all claims in the application in condition for allowance. Accordingly, it is respectfully submitted that this application be allowed and that a Notice of Allowance be issued. If the Examiner believes that a telephone conference with the Applicants' attorneys would be advantageous to the disposition of this case then the Examiner is encouraged to telephone the undersigned at 404-233-7000.

Additionally, please note that the current Amendment includes 12 total claims and 1 independent claim. Because Applicants previously paid for 20 total claims and 3 independent claims, no additional claims fees are believed due at this time. However, Applicants submit herewith the corresponding fee for a Petition for a One-Month Extension of Time to Respond to the Office Action. If our assessment of any fees due is in error, please charge any fees that might be due or credit any overpayment to our Deposit Account No. 50-3537.

Respectfully submitted,

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